Cheatgrass Die-off as a Restoration Opportunity

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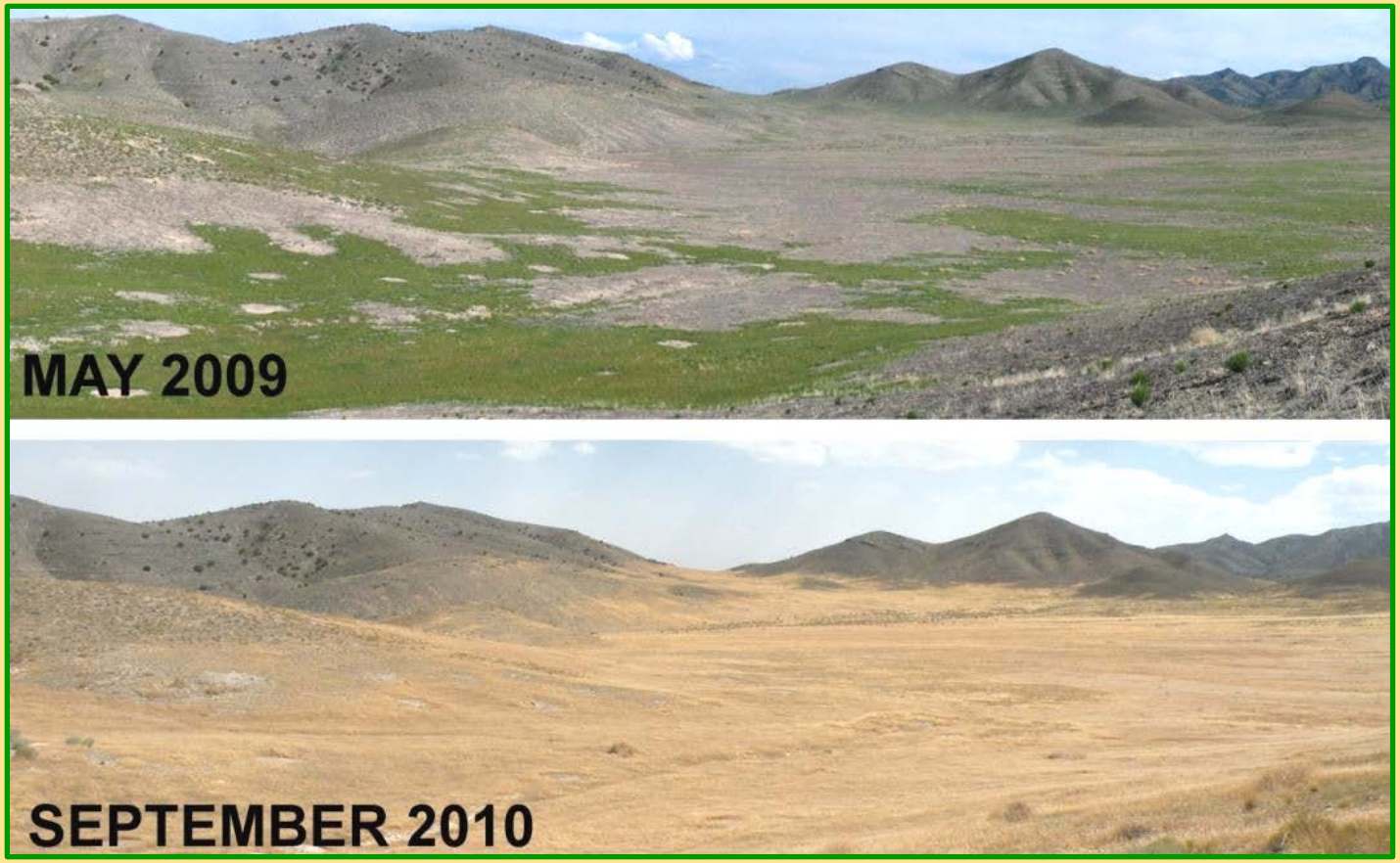
What Is a Cheatgrass Die-off?

Cheatgrass die-off is caused by emergence failure of this annual grass in an area previously occupied by a dense cheatgrass monoculture.

Die-offs vary in size from a few hundred square feet to many hundreds of acres.

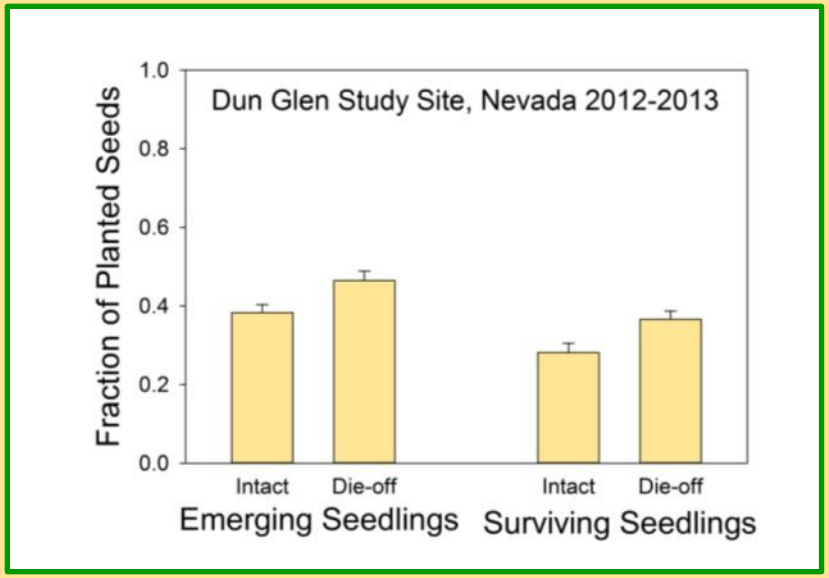
Large die-offs are areas of management concern because of forage loss and potential for erosion.

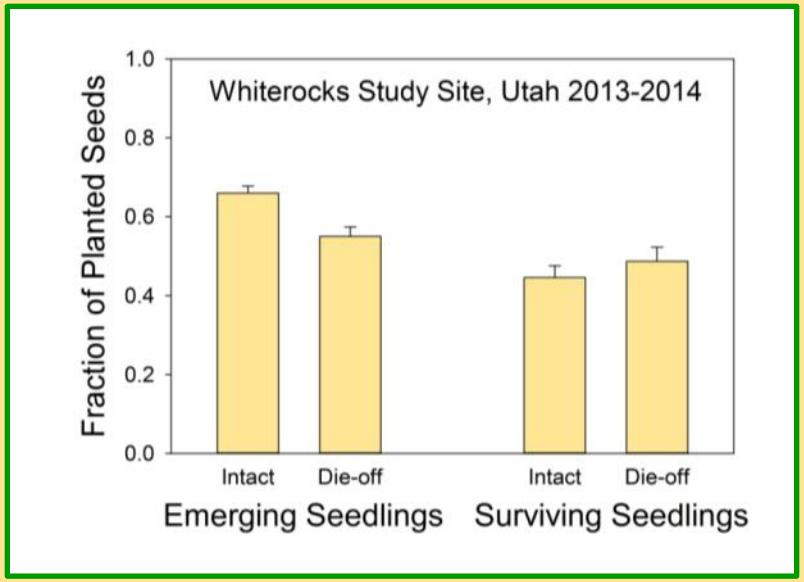
Die-offs Are Usually Transient



Lost Dog Study Site, Skull Valley, Utah

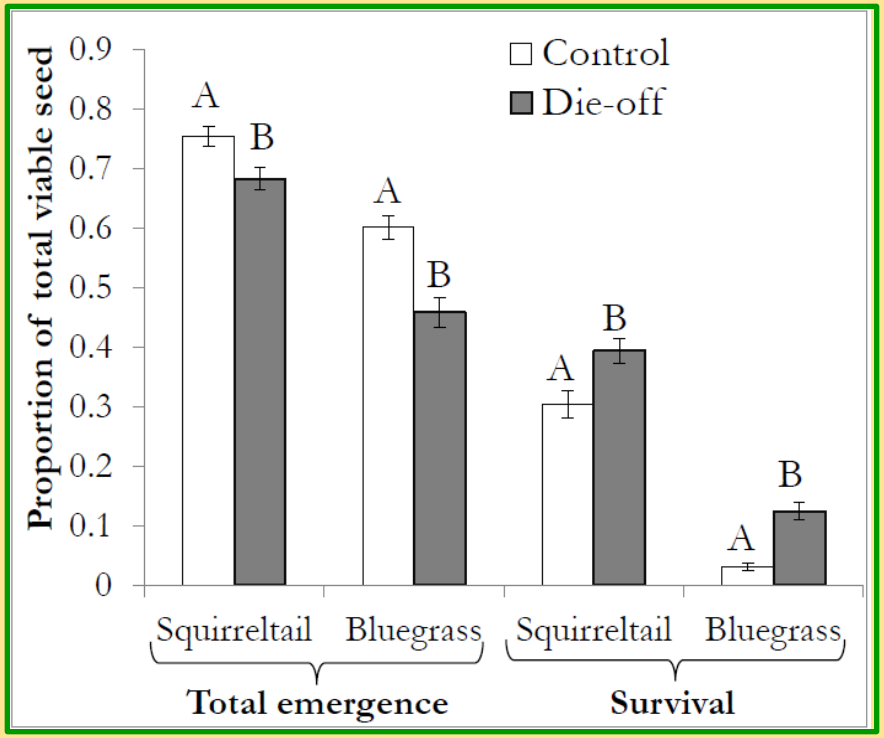
Can Cheatgrass Establish into Die-offs? Yes.

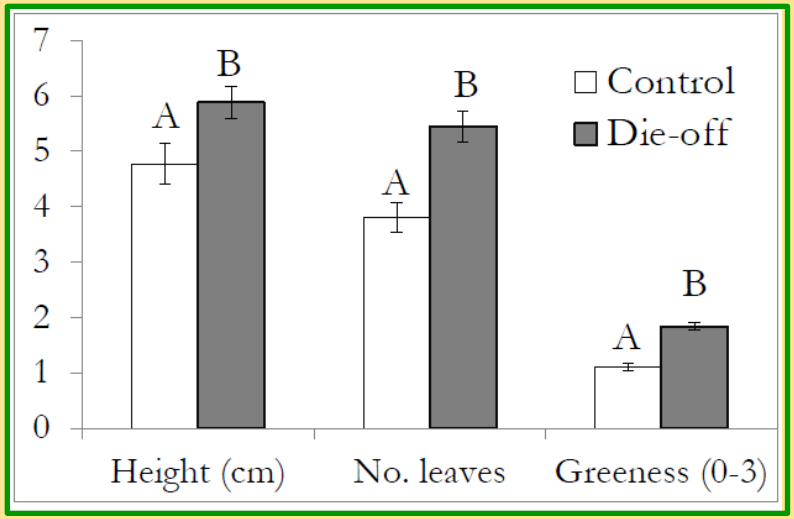




Cheatgrass emergence and survival from planted seeds were similar in die-off areas and adjacent intact stands.
From Joshua Nicholson, MS thesis, Brigham Young University, 2014

Can Native Plants Establish into Die-offs? Yes!





Seedling emergence was somewhat lower in the die-off at Dun Glen, but survival and growth were significantly increased.
From Owen Baughman, MS thesis, University Nevada Reno, 2014

What Causes Die-offs?

Although there are many hypotheses regarding the causes of cheatgrass die-offs, our research over the past four years has produced strong evidence for the following hypothesis:

Cheatgrass stand failure is caused by a complex interaction among multiple soilborne fungal pathogens.

Black Fingers of Death
Pyrenophora semeniperda

This fungal pathogen attacks seeds in the seed bank

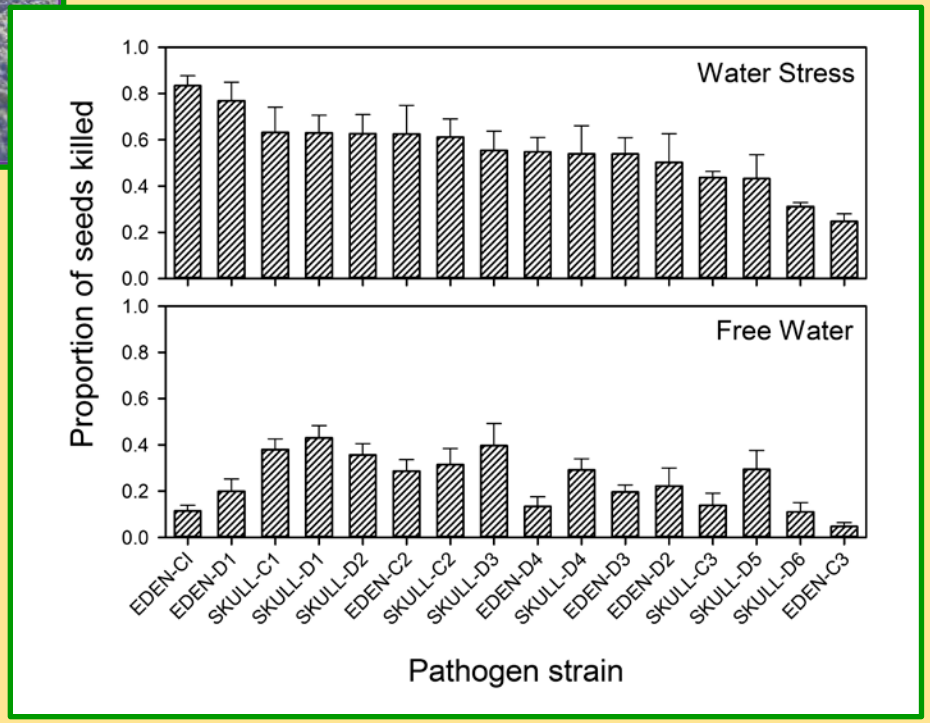
Its primary prey is dormant seeds in the persistent seed bank

It has limited ability to kill germinating seeds and probably plays no direct role in stand failure (die-off)

Stand recovery following die-off is strongly influenced by this pathogen, which can sometimes kill >99% of the seeds in the persistent seed bank.

Fusarium Seed Rot

Fusarium seed rot is caused by one or more undescribed species in the Tricinctum group of the fungal genus *Fusarium.* This disease is believed to be the primary cause of most cheatgrass stand failure.



Bleach Blonde Syndrome

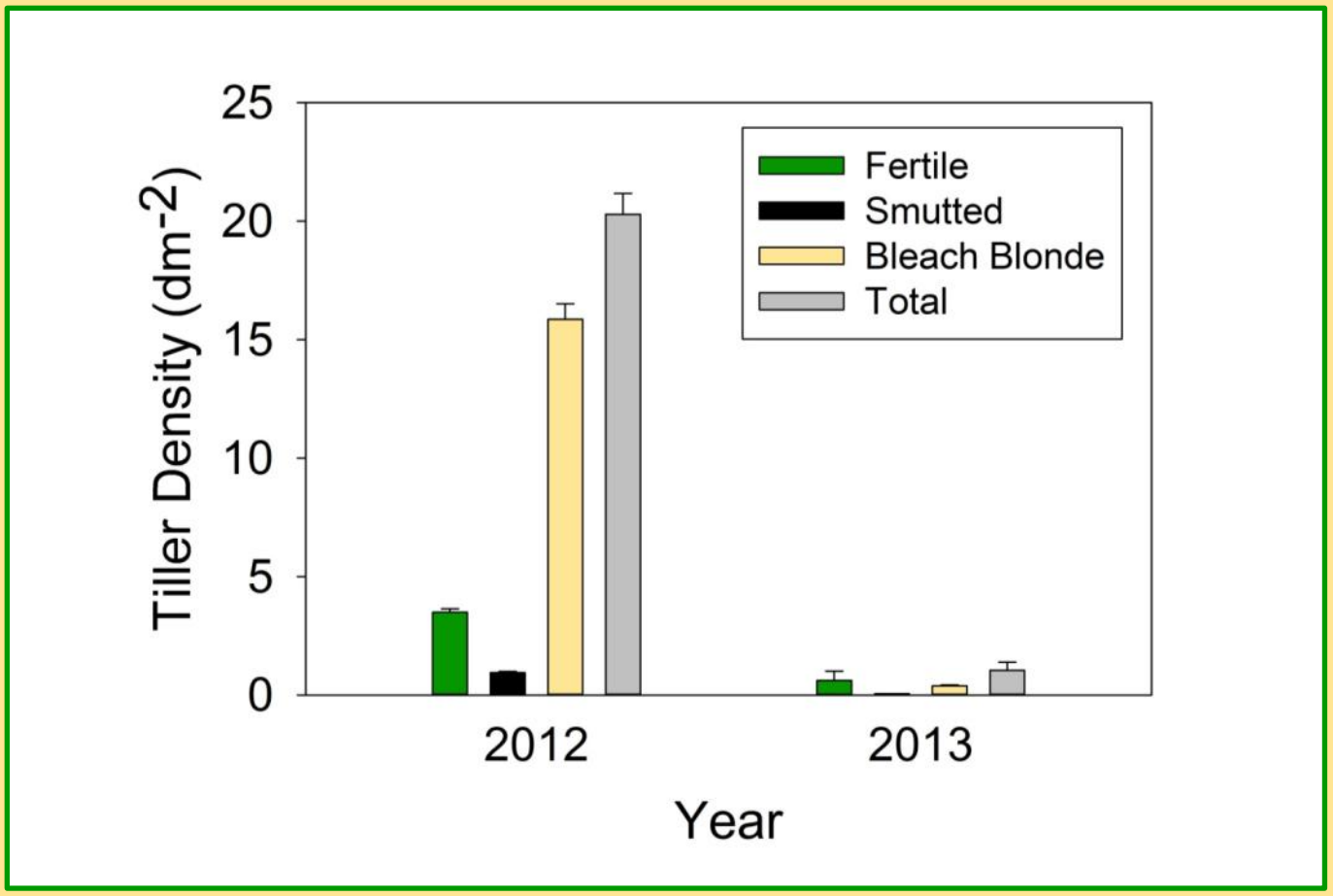
Bleach blonde syndrome is a newly discovered disease caused by an undescribed taxon in the fungal family Rutstroemiaceae. It appears to set the stage for stand failure.

The Legacy of a Bleach Blonde Epidemic

Bleach blonde epidemic
Year One

Stand failure
Year Two

The Legacy of a Bleach Blonde Epidemic



Soil Fungistasis and Die-off Cycles

- The bleach blonde pathogen is activated by a specific stimulus from the host roots at high host density.
- The Fusarium seed rot pathogen is always present, but it is suppressed by the soil microbial community at low labile carbon (aka carbohydrate) levels, that is, through the process of fungistasis.
- A pulse of labile carbon can 'wake up' the Fusarium and cause a die-off.
- A possible source of this pulse of labile carbon is carbohydrate-rich bleach blonde litter.
- Post-die-off, the labile carbon is again tied up by the microbial community, and disease levels drop dramatically the following year.

Testing the Soil Fungistasis Hypothesis

Die-off near the Great Salt Lake - 2014

Can Adding Labile Carbon Cause a Die-off?

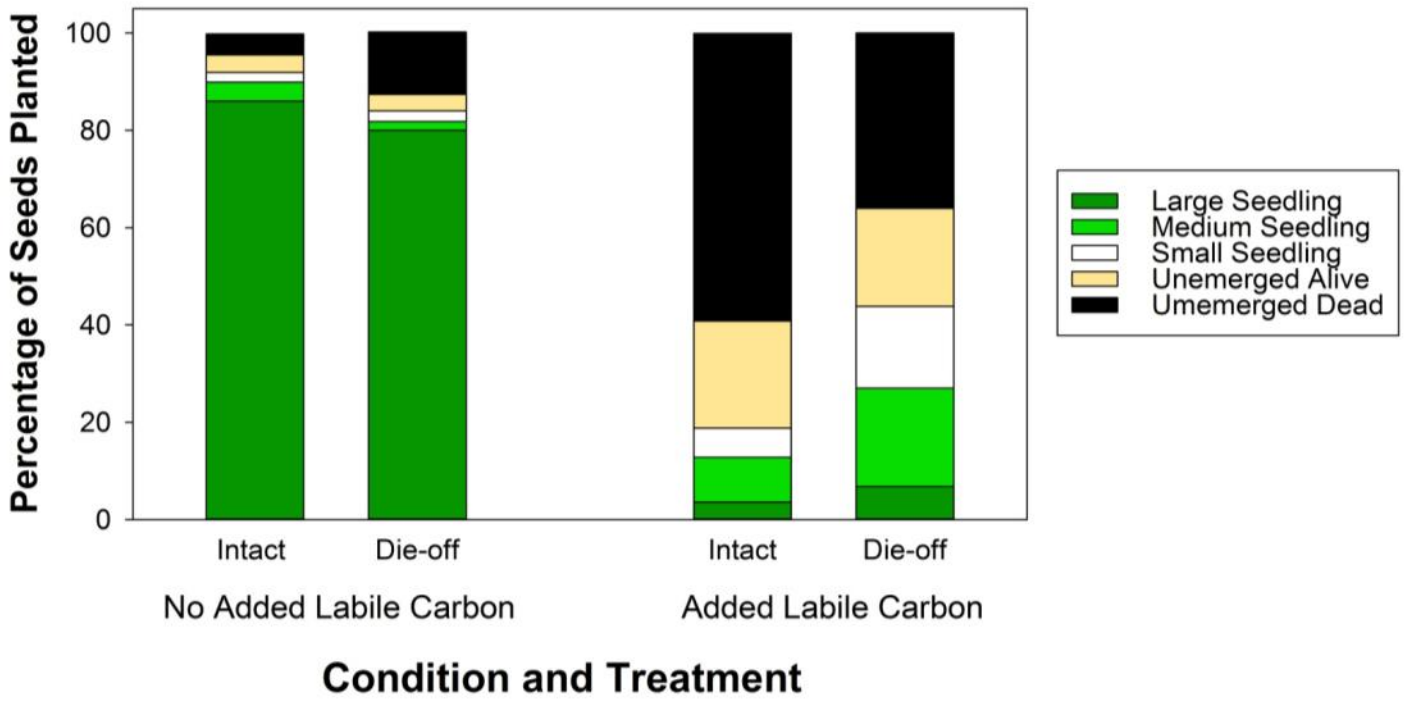
- Collected 40 ring microcosms, 20 each from recent die-off and intact cheatgrass areas in Paradise Valley near Winnemucca, Nevada in August 2014
- Each ring was planted with 50 non-dormant pink-dyed cheatgrass seeds
- Half of the rings received a labile carbon addition and half did not
- All rings were watered to field capacity and incubated under lights at room temperature for 7 days
- Emerged seedlings were classified as large (ca.>3 cm long), medium (1-3 cm long), or small (<1 cm long)
- Unemerged seeds were excavated and placed in petri dishes for 3 days.
- Seeds were scored either as unemerged alive (germinated) or unemerged dead.
- Data were analyzed using two-way ANOVA for a randomized design.

Die-off in a Dish?
Just Add Sugar

No added labile carbon

Added labile carbon

Adding Labile Carbon to Ring Microcosms



A Possible Tool for Restoration

If we can predict or manipulate disease in the field to decrease cheatgrass competition in the context of restoration seeding, this could make it possible to restore large areas now dominated by near-monocultures of this plant, which are commonly considered impossible to seed successfully.

This would uncouple the restoration seeding process from the post-fire rehabilitation process, which is primarily undertaken for a different purpose (soil stabilization).

In turn, this would permit a longer-term planning window and a more restoration-focused approach, resulting in a higher probability of seeding success.

Some Unanswered Questions

- What combination of environmental and biotic factors causes the complex spatial patterns of die-off observed on the landscape?
- Are there any other pathogens involved?
- Can die-off probability be evaluated by determining pathogen inoculum loads in the soil using molecular genetic techniques?
- Can die-offs be created by adding labile carbon, and to what extent does this depend on the *in situ* pathogen load?

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